

Vortical Sea-Surface Features Generated by a Submerged Body in a Current Field

Shih Tang

Air-Sea Interaction Laboratory

College of Marine Studies, University of Delaware

Lewes, DE 19958

phone: (302) 645-4214 fax: (302) 645-4201 e-mail: stang@udel.edu

Award # N00014-97-0749

LONG-TERM GOAL

The long-term goal is to contribute to our understanding of sea-surface roughness as influenced by various air-sea interacting processes. In particular, we are interested in identifying the sea-surface features generated by submerged bodies under various environmental conditions.

OBJECTIVES

Scientific objectives are aimed to quantify the modification of sea-surface roughness by a submerged body under various wind and current conditions, and to establish a proper algorithm to identify associated vortical surface features. It is anticipated that the results will be beneficial to shallow water mine detection with remote sensors.

APPROACH

Extensive laboratory experiments will be performed at our Wind-Wave-Current Research Facility (WWCRF) under various controlled wind and current conditions. Spheres of various diameters will be placed separately at several depths. The sea-surface undulations will first be recorded on video tapes, then a two-dimensional scanning laser slope gauge (SLSG) will be deployed to map the spatial and temporal features of the surface. The video images will be processed to provide general characteristics of eddies, such as the frequency of occurrence, the location of first appearance, and the propagation speed. On the other hand, the SLSG data will be processed to provide quantitative descriptions of these features in both spatial and temporal domains. Furthermore, the observed surface features will be compared with the turbulence structure of aqueous flow; the latter will be measured with our hot-film anemometer (TSI IFA-300). To substantiate our efforts, either radar or IR measurements will be conducted jointly by our collaborators from Naval Research Laboratory (NRL); laboratory results will be documented for modeling effort.

WORK COMPLETED

Video imaging: Sea-surface images under various experimental conditions were recorded on a CCD tapes. The general characteristics of vortical features were derived.

SLSG efforts: A series of experiments were conducted. The spatial and temporal features of vortical features were successfully derived from our SLSG measurements. Partial results were compiled and documented. We have nearly finished processing the remaining data.

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 1998		2. REPORT TYPE		3. DATES COVERED 00-00-1998 to 00-00-1998	
4. TITLE AND SUBTITLE Vortical Sea-Surface Features Generated by a Submerged Body in a Current Field				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) University of Delaware, College of Marine Studies, Newark, DE, 19716				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES See also ADM002252.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 5	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

Aqueous flow: We have completed the acquisition and installation of the hot-film anemometry system for the proposed turbulence measurements in the aqueous flow, These measurements are in progress.

RESULTS

The vortical features were clearly shown in CCD images. The appearance of these features was found to be dependent of Froude and Reynolds numbers. The generation of secondary vortices, however, remains to be verified with aqueous flow measurements. The eddies' appearance is accompanied by the disruption of thermal boundary, the associated temperature rise is also shown in the IR images in a separate experiment at WWCRF by Smith et al. (1997).

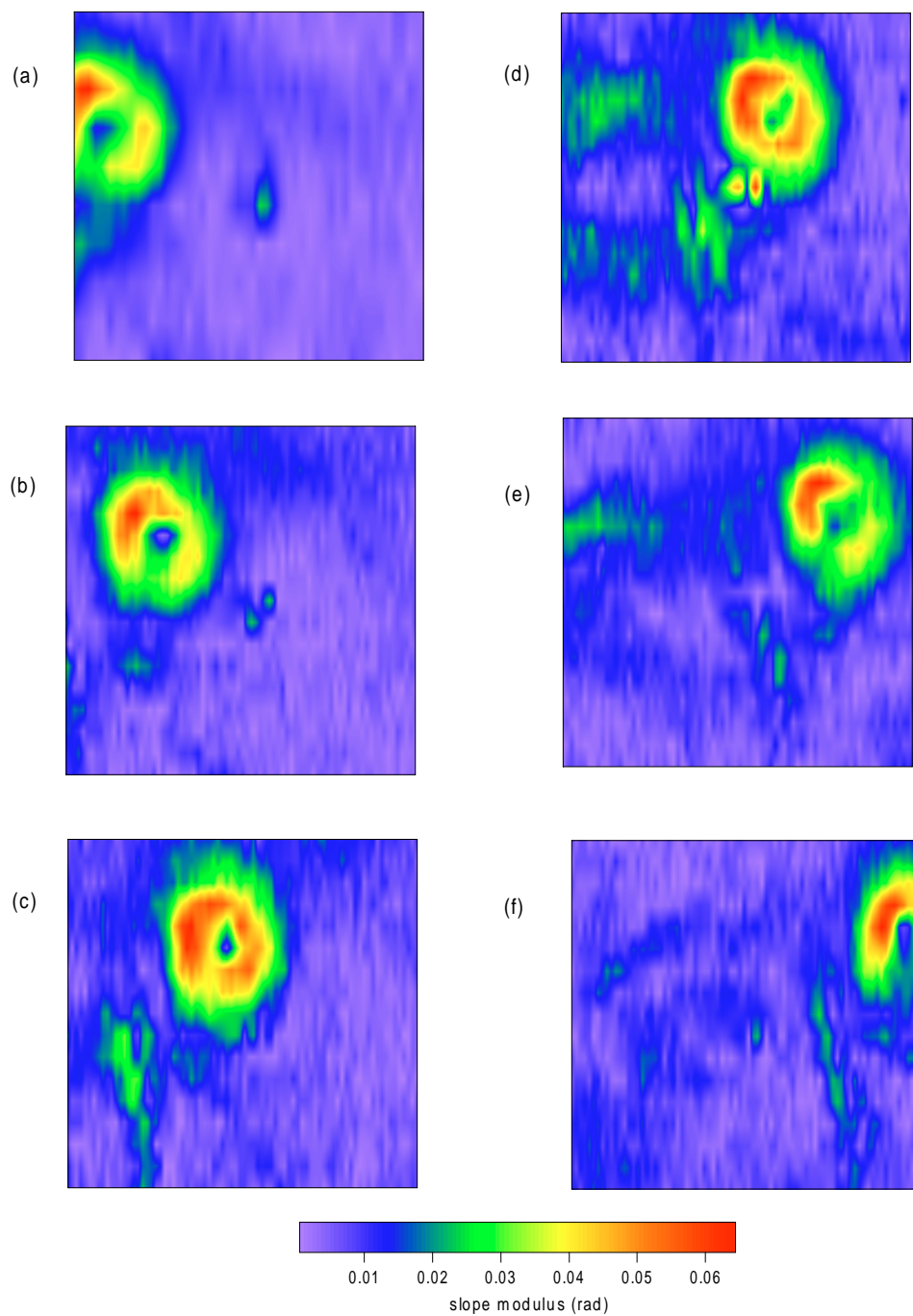


Figure 1. Slope mappings as eddies pass SLSG's window. The time gap between two adjacent images is 51 ms; the physical size of these images is 8 cm x 8 cm.

Detailed spatial and temporal features were clearly mapped with our SLSG. As an example, the passage of an eddy through the SLSG's $8\text{ cm} \times 8\text{ cm}$ window at the time step of 51 ms is shown in Figure 1; the color bar indicates the slope values. The vortical eddy features are propagating from left to the right at the speed about 20 cm s^{-1} ; quite steep slopes associated with these eddies are observed. The dimples associated with these features shown in the figure are in centi- to milli-meter scales.

These fine-scale variations may contribute to a subtle influence on radar sea returns. Note that the vortical feature is three dimensional, this is indicated by the equal slope components as vortices appeared in the SLSG's footprint, as shown in Figure 2. It is obvious that Figure 2 indicates that slope mapping is adequate in indentifying the vortical features.

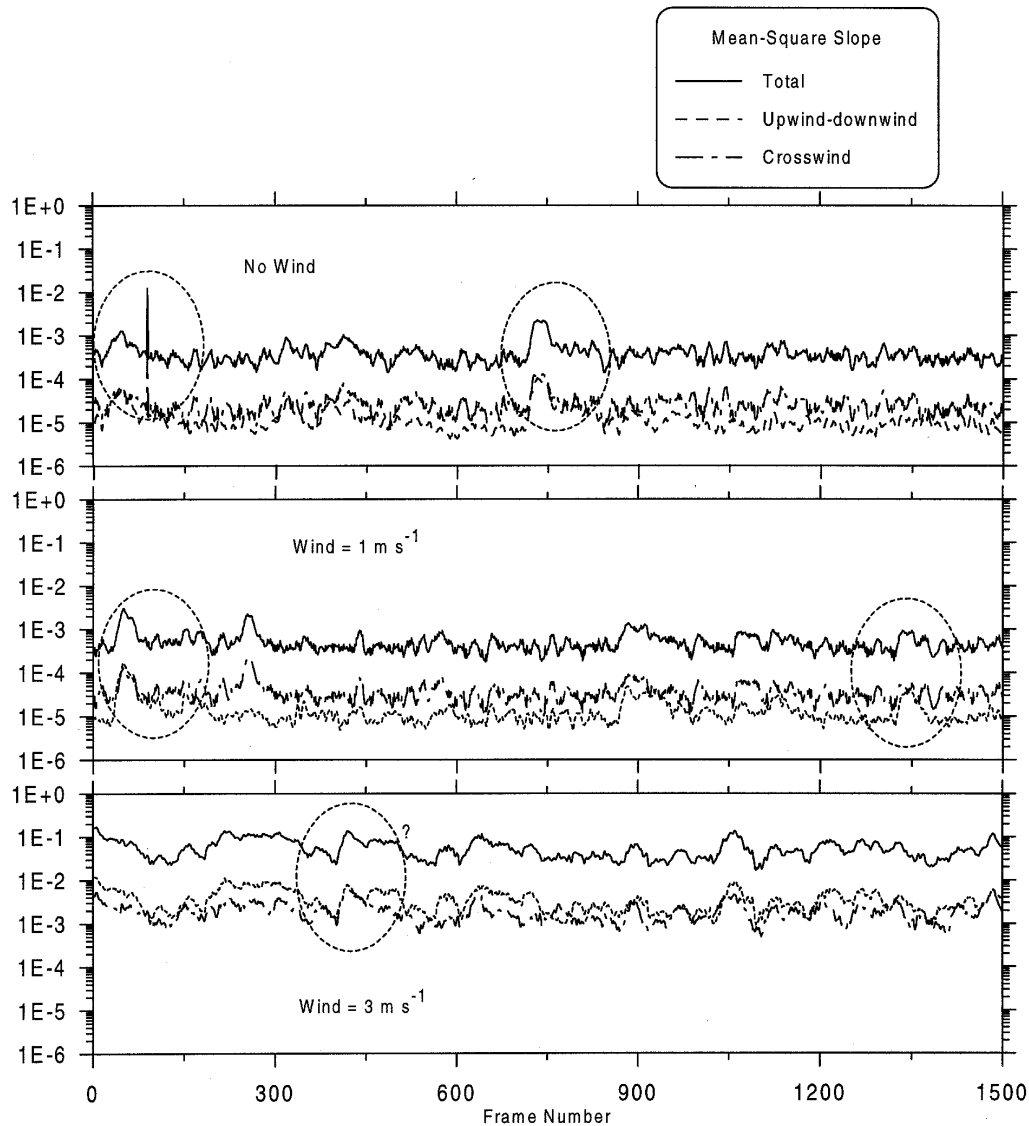


Figure 2 - Mean-square slopes at each frame. Surface slopes are evenly distributed as eddies appeared (dotted circles).

Figure 2. Mean-square slopes at each frame. Surface slopes are evenly distributed as eddies appeared (dotted circles).

IMPACT/APPLICATION

These surface features offer a quite unique opportunity for detection of nearshore mines with remote sensors. For example, the imaging radar, which receives signals of the sea-surface feature, is a potential candidate for such operations. Our effort in characterizing these features under various environmental conditions will certainly lead to a proper algorithms for mine detection.

TRANSITIONS

Detailed current profiles at various sections along the tank were made available for modeling effort at NRL. Our experimental setup was also used for IR measurements.

RELATED PROJECTS

The features derived from our CCD and SLSG measurements were compared with the thermal signatures obtained from a separate experiment with an IR camera by Geofreey Smith (NRL) and Richard Leighton (NRL).

REFERENCES

Longuet-Higgins, M. S. 1976: Surface manifestations of turbulent flow. *Journal of Fluid Mechanics*, 308, 15-29.

Smith, G., Leighton, R., Tang, S. and Chen, S. 1997: The thermal signature of eddies shed from a sphere. ONR Workshop on Free-Surface and Wall Bounded Turbulence and Turbulent Flows, California Institute of Technology, Pasadena, California.

Tang, S., Chen, S. and Wu, J. 1997: Sea surface features generated by the submerged bodies in a current field. ONR Workshop on Free-Surface and Wall Bounded Turbulence and Turbulent Flows, California Institute of Technology, Pasadena, California.

PUBLICATIONS

Tang, S., Chen, S. and Wu J. 1997: Vortical surface features from a submerged body in a current field, *Proceedings of the Nineteenth Conference on Ocean Engineering*, Taichung, Taiwan.

Tang, S., Wu, J., Smith, G. and Leighton, R. 1998: Surface features modified by a submerged body in a current field, *Third International Technology and Mine Problem Symposium*, Naval Postgraduate School, Monterey, California.

Chen, S., Tang, S. and Wu, J. 1998: Sea-surface signatures of vortex pairs under the wind influence. *Annual Meeting, American Geophysical Union*, San Franscisco, California.